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DESCRIPTION

ELECTROSTATIC ATOMIZING DEVICE AND HUMIDIFIER USING THE SAME

TECHNICAL FIELD

The present invention relates to an electrostatic atomizing device for emitting a liquid in the form of tiny ionized particles and a humidifier using the same.

BACKGROUND ART

Japanese Patent Publication No. 3260150 discloses a prior electrostatically atomizing device. The atomizing device utilizes capillary structure as a liquid carrier to feed the liquid to discharge end of the carrier by a capillary effect. A high voltage is applied between the carrier and a surrounding housing to emit the liquid as ionized particles from the discharge end. When the device uses the water, for example, city water, electrolytic water, PH adjusted water, mineral water, vitamin-C or amino-acid contained water, or water containing a deodorant such as fragrant oil or aromatic, minerals such as Ca or Mg possibly contained in the water will advance to the distal end of the capillary structure and react with CO_2 in the air to precipitate as CaCO3 or MgO, hindering the electrostatic atomization. Therefore, it has been a problem to require maintenance of removing the precipitants regularly.

DISCLOSURE OF THE INVENTION

The present invention has been achieved to overcome the above problem and to present an electrostatically atomizing device and the humidifier using the same which can avoid the precipitation of impurities contained in the liquid at the discharge end of the carrier for maintaining stable electrostatic atomization over a long period of use.

The electrostatically atomizing device of the present invention includes a carrier having a liquid collecting end and a discharge end opposite of the liquid collecting end, the liquid collecting end collecting a liquid for feeding the liquid to

the discharge end. The device includes a first electrode, a second electrode, and a voltage source. The voltage source applies a voltage across the first and second electrodes to charge the liquid at the discharge end, thereby emitting the liquid in the form of tiny ionized particles. The characterizing feature of the present invention is to include a steam supply which feeds a steam to the liquid collecting end of the carrier for condensation of the liquid therearound in order that the condensed liquid is fed to the discharge end of the carrier. Thus, even with the use of the liquid in which cation of Ca or Mg is dissolved, the content of Ca or Mg cation can be minimized by the effect of steam, thereby inhibiting the impurities from being fed to the discharge end of the carrier and avoiding the lowering of the electrostatic atomization by the precipitation of the impurities. Accordingly, frequent cleaning of the discharge end can be avoided to keep the stable electrostatic atomization over a long period of use.

Preferably, the case accommodating the carrier has its interior separated by a partition into a condensation compartment and a discharging compartment. The carrier extends through the partition to dispose the liquid collecting end within the condensation compartment, and the discharge end within the discharge compartment. The condensation compartment is communicated with the steam supply to be fed the steam therefrom to give the steam condensed liquid to the liquid collecting end. Thus, the condensation compartment serves as a condensation space to feed the condensed liquid effectively to the liquid collecting end.

The condensation compartment is preferably configured to make a circular flow of the steam around the liquid collecting end of the carrier. The circular flow increases the chance of contact between the steam and the carrier to improve condensation effect by cooling of the steam, assuring to feed the liquid stably to the discharge end of the carrier.

The condensation compartment may be provided with a liquid absorber for condensing the steam thereat and feeding the condensed liquid to the liquid collecting end of the carrier.

Further, the electrostatically atomizing device is preferred to include a fan producing a forced air flow, and an air duct introducing the forced air flow into between the discharge end and the second electrode. With this arrangement, the tiny ionized particles of the liquid generated between the discharge end and the second electrode is carried on the forced air flow to spread over a wide range. In this case, a baffle may be provided to shield the carrier from the forced air flow, avoiding undue evaporation of the liquid from the carrier.

Thus configured electrostatically atomizing device is preferably incorporated into an appliance such as a humidifier. The humidifier has a fan generating an forced air flow and a steam path for directing a portion of the steam from the steam supply as being carried on the forced air flow and emitting the steam outwardly. Consequently, in addition to general humidification effect by the steam, the tiny ionized particles of the liquid can be dispersed to improve skin beauty effect due to high skin penetration capability that the tiny ionized particles exhibit, as well as room deodorizing effect.

These and still other objects and advantageous features will become apparent from the detailed explanation of the preferred embodiment when taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical section of an electrostatically atomizing device in accordance with an embodiment of the present invention;

FIG. 2 is a perspective view of an atomizing unit in the above device;

FIG. 3 is a side view of the atomizing unit;

FIG. 4 is a perspective view of a humidifier incorporating the atomizing unit;

FIG. 5 is a top view of the humidifier;

FIG. 6 is a cross-section taken along line 6-6 of FIG. 5;

FIG. 7 is a cross-section taken along line 7-7 of FIG. 5; and

FIG. 8 is a cross-section illustrating a modification of the atomizing unit.

BEST MODE FOR CARRYING OUT THE INVENTION

An electrostatically atomizing device in accordance with one embodiment of the present invention is configured to ionize particulate water, for example, so as to generate ionized water particles of a nanometer size, and include an atomizing unit **M** for electrostatically atomizing the liquid, and a steam generator **S** providing a steam of water. As shown in FIG. 1, the atomizing unit **M** includes a case **30** accommodating a plurality of capillary carriers **20**. The case **30**, which is made of a first tube **31** and a second tube **32** coupled to each other, has its interior space divided by a partition **10** into a condensation compartment **33** and a discharge compartment **34**. The capillary carrier **20** extends through the partition **10** as being held thereby to define a liquid collecting end **22** at its portion projecting into the condensation compartment **33**, while defining a discharge end **21** at its pointed end of a portion projecting into the discharge compartment **34**. Extending from the first tube **31** surrounding the condensation compartment **33** is a duct **35** for introducing the steam from the steam generator **S**, thereby collecting the condensed water at the liquid collecting end of each capillary carrier **20**. The condensed water is absorbed in the liquid collected end **22**, and is accumulated in an absorber **24** which is mounted around the liquid collected end **22** and act to feed the condensed water also to the capillary carriers **20**.

A stud **36** projects from the inner bottom of the first tube **31**. A plurality of axles **38** extends from the stud **36** to support the liquid collecting ends of the capillary carriers **20**. The axles **38** and the capillary carriers **20** are located centrally within the condensation compartment **33** to define an annular space around these parts. Thus, the steam supplied into the condensation compartment **33** is caused to give a circular flow as indicted by arrows in FIG. 1, prompting the cooling effect to enhance the condensation of water, and therefore supplying the water constantly to the liquid collecting ends of the capillary carriers **20**.

The partition **10** is embedded with a first electrode **11** which is connected to the capillary carriers **20** to charge the water being carried through the carriers

20. The first electrode **11** has a terminal **12** for connection with an external high voltage source **70**. The second tube **32** surrounding the second compartment **34** has a front opening within which a second electrode **40** disposed. A high voltage generated at the high voltage source **70** is applied across the first and second electrodes **11** and **40**. The high voltage is applied continuously or in the form of a pulse across the electrode plate **40** and the partition **10**.

Each of the capillary carriers **20** is made of a porous ceramic and shaped into a porous bar having a diameter of about 5 mm and a length of about 70mm in order to feed the water collected at the liquid collecting end **22** to the discharge end **21** by the capillary effect.

The high voltage source **70** is configured to apply the high voltage having an electric field strength of 500 V/mm, for example, between the first electrode **11** and the second electrode **40**, developing an electrostatic atomization between the discharge end **21** at the distal end of the capillary carrier **20** and the second electrode **40** opposed to the discharge end such that tiny ionized water particles are emitted from the discharge end **21** towards the second electrode **40**. That is, the high voltage induces Rayleigh disintegration of the water being emitted from the discharge end, thereby generating negatively-charged water particles and emitting the mist of the tiny ionized water particles.

The second electrode **40** is molded from an electrically conductive resin and shaped into a circular electrode plate having a plurality of openings. Each opening has its periphery disposed in a closely opposed relation to the discharge end **21** to make the discharge between the periphery and the discharge end **21**. The second electrode is formed on its periphery with a terminal **42** for connection with the high voltage source **70**. The second tube **32** is fitted with a cover **37** which is made of a dielectric material and is formed with discharge ports **39** in correspondence with the openings of the second electrode **40**, as see in FIGS. 2 and 3..

Each of the capillary carriers **20** is made of the porous ceramic material of particle size of 2 to 500 μm and has a porosity of 10 to 70 % to feed the water

to the discharge end **21** by the capillary effect using minute paths in the ceramic. The ceramic is selected from one or any combination of alumina, titania, zirconia, silica, and magnesia, and is selected to have a PH at the isoelectric point lower than PH of the water in use. The basis of such selection is related to mineral components such as Mg and Ca possibly contained in the water being utilized. The mineral components contained in the water are refrained from advancing to the discharge end of the capillary carrier **20** and therefore refrained from reacting with CO_2 in the air to precipitate as MgO or $CaCO_3$ which would otherwise impede the electrostatic atomization effect. That is, the electroosmotic flow in the capillary carriers **20** can be best utilized so that Mg or Ca ions dispersed in the water is prevented from advancing to the discharge end **21**.

The partition **10** supports at its center an ionizing needle **60** which is electrically charged to the same potential as the capillary carriers **20**. The ionizing needle **60** has a pointed end projecting in the discharge compartment **34** in alignment with the discharge ends **21** of the capillary carriers **20**. The capillary carriers **20** are evenly spaced in a circle concentric to the ionizing needle **60**. The ionizing needle **60** is opposed to a center opening of the second electrode **40** to cause a corona discharge therebetween, thereby negatively charging molecules such as oxygen, oxide, or nitride in the air to generate negatively charged ions, while restraining the generation of ozone. Thus, by applying of the high voltage negative potential to the ionizing needle **60** and the capillary carriers **20**, the negatively charged ions are generated from the ionizing needle **60** concurrently with the atomization of the liquid at the discharge ends **21**.

An air introduction chamber **50** is formed on one circumferential portion around the second tube **32**. The air introduction chamber **50** is connected through an air duct **94** to a fan **90** in order to introduce a forced air flow generated at the fan **90** and direct the air flow in the discharge compartment **34**, whereby the resulting air flow goes from the discharge compartment **34** through the discharge ports **39** of the cover **37**. The ionized tiny water particles of

negative charge generated between the discharge end **21** and the second electrode **40** as well as the negatively charged ions generated between the emitter needle **60** and the second electrode **40** are carried on the air flow to be spread in the form of a mist into a wide space. A baffle **52** is disposed between the discharge compartment **34** and the air introduction chamber **50** so as to protect the capillary carriers **20** from being directly exposed to the forced air flow being introduced to the air introduction chamber **50**, but to allow the forced air flow to be directed through an inlet **54** at the front end of the baffle **52** to between the discharge ends **21** of the capillary carriers **20** and the second electrode **40**.

FIGS. 4 to 7 illustrate one example in which the atomizing unit **M** is incorporated into the humidifier **100**. The humidifier **100** includes a housing **101** with a detachable tank **110**, the housing **101** accommodating therein a steam generator **S**, a fan **90**, and a high voltage source **70**. The steam generator **S** is configured to heat the water being supplied from the water tank **110** to generate the steam, which is discharged through a steam discharge path **120** and out of a steam port **122** at the front of the housing **101**, as shown in FIGS. 6 and 7. The steam discharge path **120** has its portion communicated with the duct **35** for supplying the steam to the condensation compartment **33** of the atomizing unit **M**. The fan **90** is communicated through an air path **92** with the steam discharge path **120** immediately upstream of the steam port **122**, thereby giving off the steam out of the steam port **122** as being carried on the forced air flow from the fan **90**. The air path **92** is also communicated with the air duct **94** of the atomizing unit **M** to direct the part of the forced air flow into the discharge compartment **34** by way of the air introduction chamber **50**, whereby the tiny ionized water particles and the negative ions generated within the discharge compartment **34** are carried on the forced air flow to be emitted out of the discharge port **39** of the cover **37**.

Although the illustrated embodiment is configured to supply the part of the steam from the steam generator **S** into the atomizing unit **M** while emitting the rest of the steam out of the steam port **122**, it may be configured to supply

the entire steam into the atomizing unit **M**.

When the mist of the tiny ionized water particles caused by the electrostatic atomization is generated at a rate of 0.02 ml/m within an electric field strength of 500 V/mm or more with the use of the capillary carrier **20** of which tip diameter is 0.5 mm or below, the mist contains the very fine ionized particles having the nanometer particle size of 3 to 100 nm, which react with the oxygen in the air to give the radicals such as hydroxyl radicals, superoxides, nitrogen monoxide radicals, and oxygen radicals. The mist of the tiny ionized water particles, when released into a room, can deodorize substances contained in the air or adhered to the walls. The following are reaction formulas between the radicals and various kinds of odor gases.

ammonia :	$2NH_3 + 6 \cdot OH \rightarrow N_2 + 6H_2O$
acetaldehyde :	$CH_3CHO + 6 \cdot OH + O_2 \rightarrow 2CO_2 + 5H_2O$
acetic acid :	$CH_3COOH + 4 \cdot OH + O_2 \rightarrow 2CO_2 + 4H_2O$
methane gas :	$CH_4 + 4 \cdot OH + O_2 \rightarrow CO_2 + H_2O$
carbon monoxide :	$CO + 2 \cdot OH \rightarrow CO_2 + 4H_2O$
nitrogen monoxide :	$2NO + 4 \cdot OH \rightarrow N_2 + 2O_2 + 2H_2O$
formaldehyde :	$HCHO + 4 \cdot OH \rightarrow CO_2 + 3H_2O$

In addition, the tiny ionized water particles of nano-meter size can well penetrate into keratinous membrane in human skin to improve moisture retention of the skin.

FIG. 8 illustrates a modification of the above atomizing unit M which is similar in structure to the above atomizing unit except for a concave **23** formed in the liquid collecting end **22** of the capillary carrier **20**. The similar elements are designated by the same reference numerals. The concave **23** increases the contact area of the capillary carrier **20** with the steam to obtain more amount of the condensed water, enhancing the efficiency of supplying the water to the capillary carriers **20**.

Although the above embodiment is explained with reference to an example in which the water is utilized to generate mist of the tiny ionized water

particles, the present invention is not limited to the particular embodiment, and can be applicable to the use of the various liquids other than the water. The available liquid includes the water containing valuable components such as vitamin C, amino acids, a deodorant such as fragrant oil or aromatic, and includes a colloidal solution such as a make-up lotions.